

**69920** - 60 grams  
**69940** - 428 grams  
**69960** - 508 grams  
 Shaded Soils

DRAFT

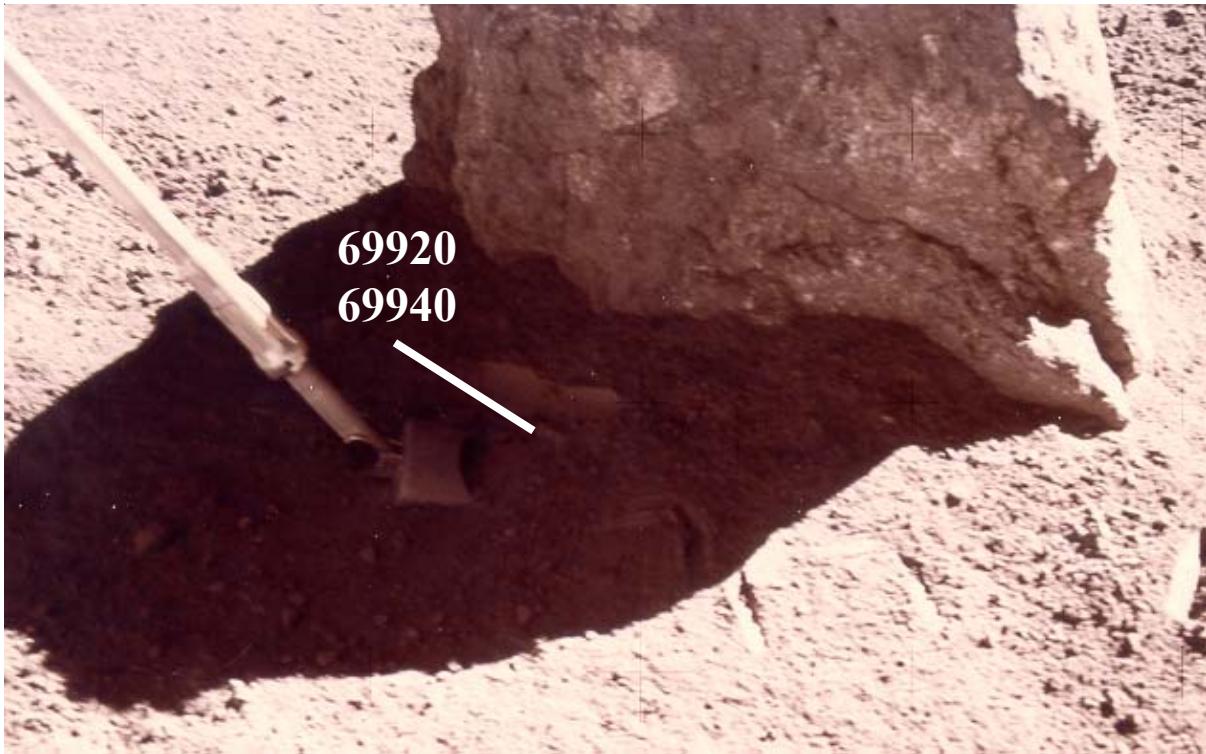


Figure 1: Soil samples collected from shaded area of small (0.5 m) boulder at station 9, Apollo 16. AS16-107-17562. Area may not be permanently shaded at all sun angles. However, 69960 was collected from under the rock, after it was rolled over, and was thus permanently shaded..

LMP We got to get a skim.  
 CDR Can we skim where the pristine sample was?  
 CC We'd like a skim next to it.  
 LMP No, they want it right beside it, right there  
 CDR You can't see any of that stuff.  
 LMP Yeah, I can see. Okay here we go. Get me a bag ready.  
 LMP Tony, I probably got 5 mm on that skim.  
 CDR That's going in bag 376? (69920)  
 CDR Okay. Charlie's scoop is being taken right under the –  
 LMP You got it. Okay, there you go. That's going in bag 377, Houston. (69940)  
 CC We'd like you to get that CSVC. (69001)  
 - -----  
 CC John. Can you turn that over by yourself?  
 - -----  
 LMP He did it, Houston! He did it.  
 CC So you can not only sneak up on them, you can flip the over, huh?  
 CDR Yeah. That's a biggie. Man, it looks like it's been sitting there for quite a while. Look at that soil underneath. Before I

stomp all over it, Charlie, sneak over here and let's get some of this soil.

LMP Yeah, okay. Look at that soil! It's all cake looking, isn't it? And it looks just like an alkali flat in the cake that under it, Tony. And that's right from the deepest part. That sample is right in the middle, which happens to be the deepest penetration that the boulder made. There's a sackful. (69960 bag 379)

## Introduction

69920 and 69940 were collected from the shade cast by a small boulder (figure 1). 69960 was soil collected from under the boulder after it was rolled over. 69920 was called a “skim soil”, because it was collected from the top 1 cm. 69940 was collected beneath 69920. Rock samples 69935 and 69955 are from the top and bottom of the boulder. 69001 is a special core (CSVC) taken nearby (Sutton 1981).

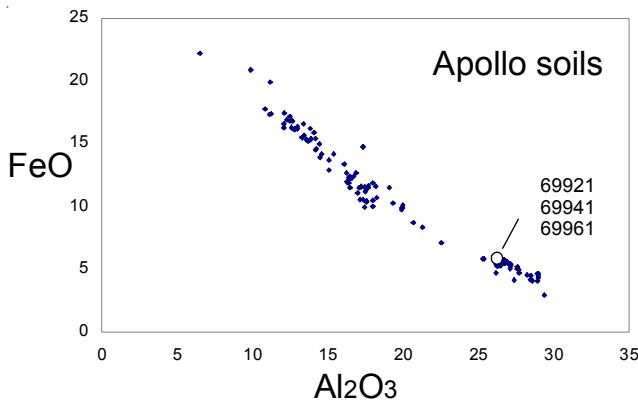


Figure 2: Composition of samples.

## Petrography

These are very mature soils with about 65 % agglutinates, and high carbon and nitrogen contents (figure 3). The maturity index ( $\text{Is}/\text{FeO}$ ) determined for 69921, 69941 and 69961 is 90, 85 and 92, respectively (Morris 1988). The grain size distribution was determined by Butler et al. (1973)(figure 4).

The mineralogy of 69941 is interesting in that several grains of pyroxene and olivine are very Mg-rich (figure 5). Some plagioclase grains are also very Ca-rich (Taylor and Carter 1973).

## Chemistry

The chemical composition of these three soils is given in the tables herein (figures 2 and 6).

Kothari and Goel (1973) determined 140 ppm nitrogen in both 69941 and 69961. Moore et al. (1973) reported 170 ppm carbon in 69941 and 140 ppm in 69961 (figure 2). Gibson and Moore (1973) reported 765 ppm sulfur in 69941 and 794 ppm sulfur in 69961.

## Cosmogenic isotopes and exposure ages

The cosmic-ray-induced activity  $^{26}\text{Al} = 305 \text{ dpm/kg.}$ ,  $^{22}\text{Na} = 86 \text{ dpm/kg}$  and  $^{53}\text{Mn} = 630 \text{ dpm/kg}$  for skim soil 69921 is quite high (Fruchter et al. 1981) – apparently due to erosion off the top of the adjacent

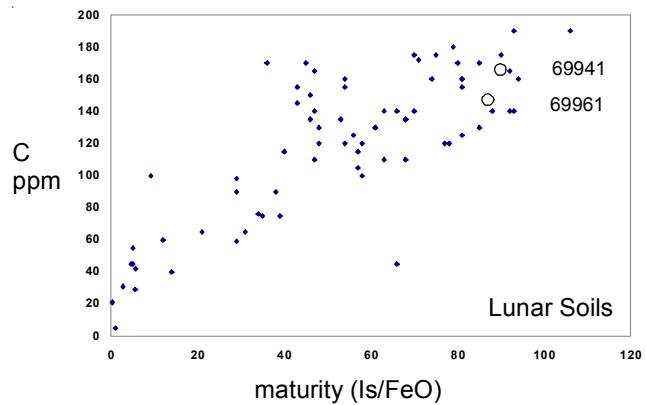


Figure 3: Carbon content and maturity of lunar soils showing Apollo 16 station 9 soils.

boulder (figure 7). The cosmic-ray-induced activity beneath the boulder (66961) is also quite high considering the shielding (Wrigley 1973, Fruchter et al. 1981).

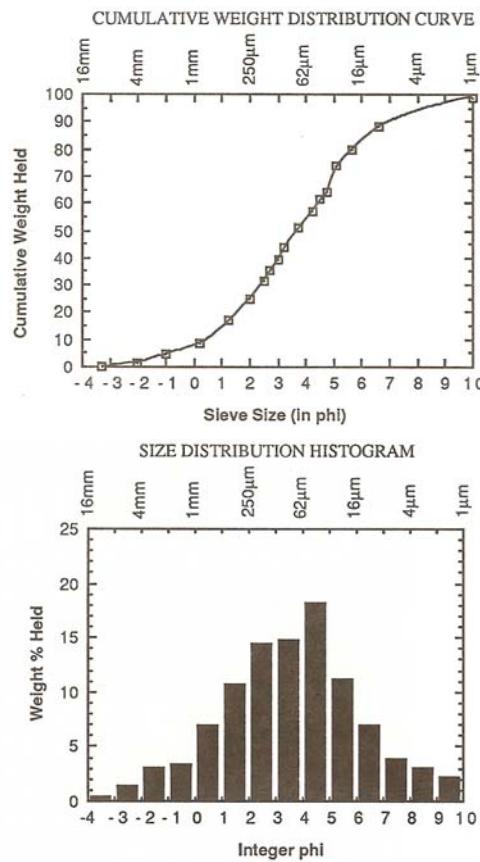


Figure 4: Grain size distribution for 69941 (Butlesr et al. 1973).

## Mineral Mode 69940 (63-125 microns)

LSPET 1972

Agglutinates	64%
Basalt	1
Anorthosite	1
Breccias	14
Plagioclase	7
Pyroxene 2	
Glass	10

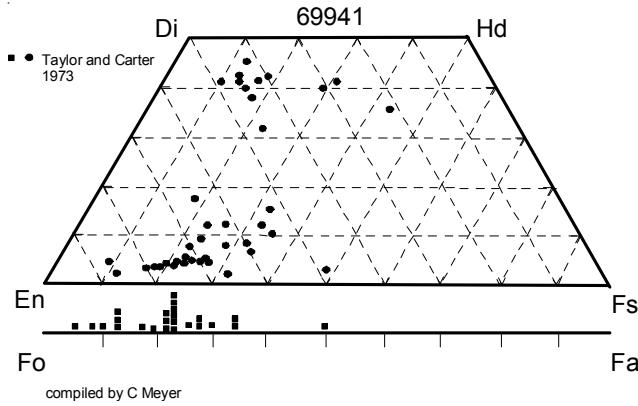


Figure 5: Composition of pyroxene and olivine in 69941 (Taylor and Carter 1973).

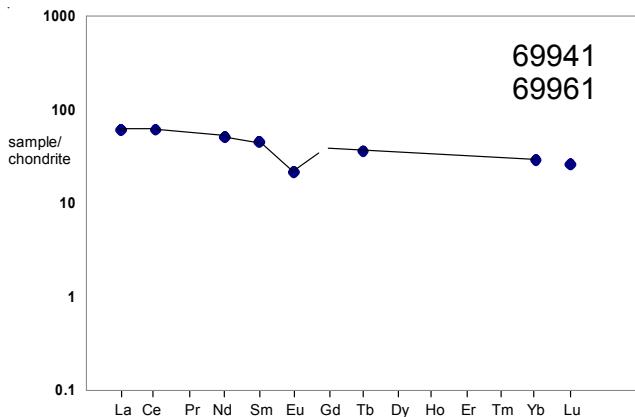


Figure 6: Normalized rare earth element diagram for 699xx soils (Haskin et al.).

## Other Studies

Rao et al. (1979), Venkatesan et al. (1980) and Nautiyal et al. (1981) studied the SCR tracks and noble gases in 69921 and 69941 (figure 8).

Kirsten et al. (1973), Behrmann et al. (1973) and Walton et al. (1973) each reported rare gas contents. Becker et al. (1975, 1976, 1980) and Kerridge et al. (1975) studied the isotopic ratios of nitrogen and other elements.

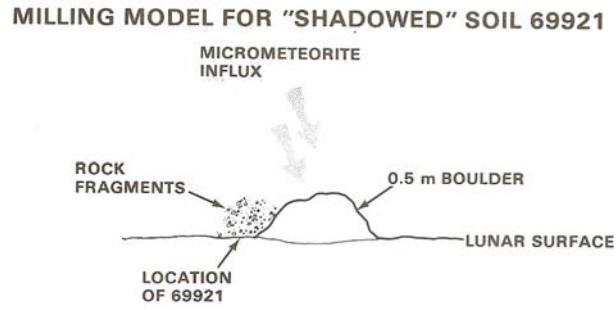


Figure 7: Fruchter's explanation for high  $^{26}\text{Al}$  in 69941.

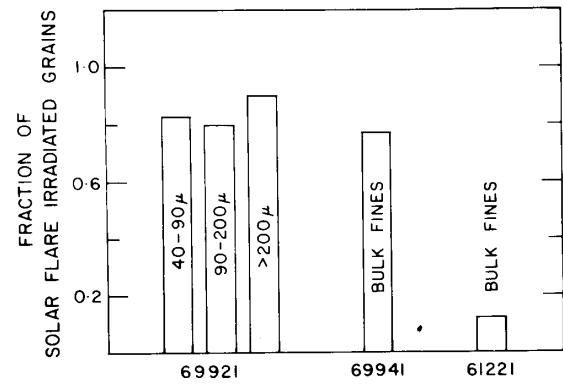


Figure 8: Cosmic ray tracks in 69921 (Rao et al. 1979).

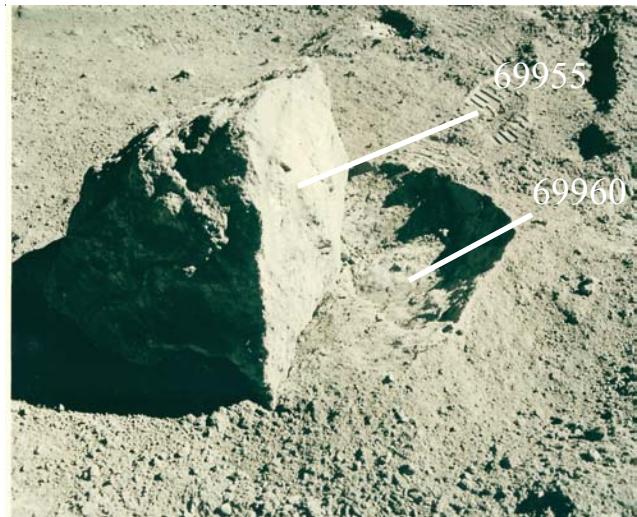
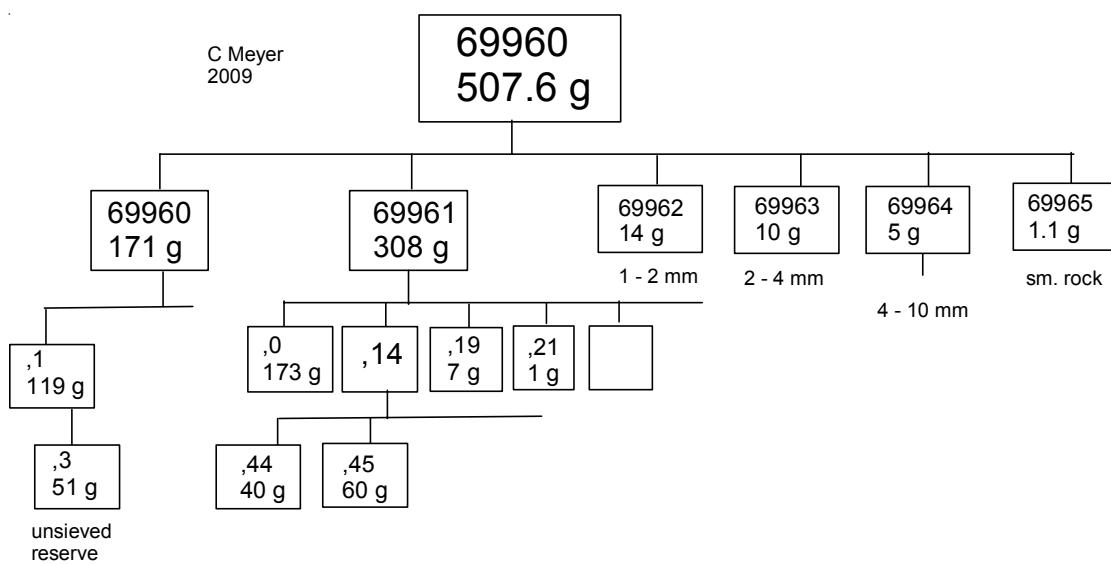
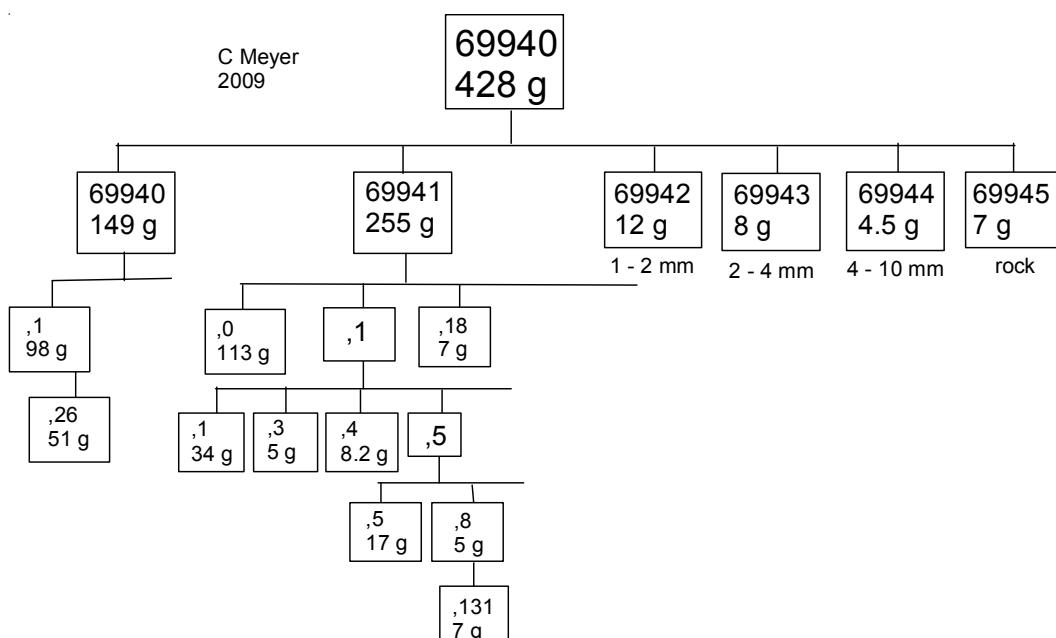
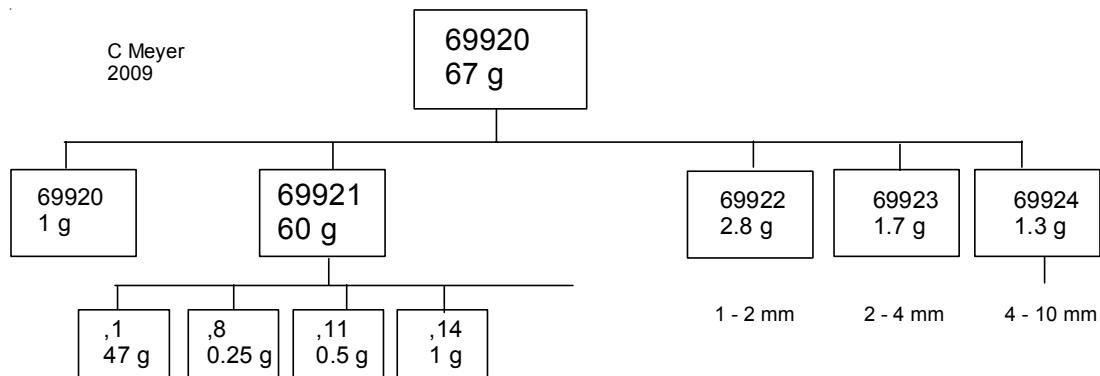


Figure 9: Bottom side of boulder after tipping over. AS16-107-17573.



**Table 1. Chemical composition of 69921.**

reference	Rose73	Laul73	Rancitelli73	
<i>weight</i>				
SiO <sub>2</sub> %	45.21	(a)		
TiO <sub>2</sub>	0.59	(a)	0.64	0.6 (b)
Al <sub>2</sub> O <sub>3</sub>	26.2	(a)	26	26.3 (b)
FeO	5.54	(a)	5.7	5.6 (b)
MnO	0.07	(a)	0.07	0.07 (b)
MgO	6.35	(a)	6.3	6.3 (b)
CaO	15.35	(a)	14.7	15 (b)
Na <sub>2</sub> O	0.53	(a)	0.47	0.46 (b)
K <sub>2</sub> O	0.14	(a)	0.11	0.11 (b) 0.12 (c)
P <sub>2</sub> O <sub>5</sub>	0.12	(a)		
S %				
<i>sum</i>				
Sc ppm	10	(a)	10	10 (b)
V	19	(a)	27	25 (b)
Cr	958	(a)		
Co	21	(a)	30	28 (b)
Ni	348	(a)	550	(b)
Cu	10	(a)		
Zn	24	(a)		
Ga	4	(a)		
Ge ppb				
As				
Se				
Rb	3.2	(a)		
Sr	210	(a)		
Y	43	(a)		
Zr	144	(a)	170	170 (b)
Nb				
Mo				
Ru				
Rh				
Pd ppb				
Ag ppb				
Cd ppb				
In ppb				
Sn ppb				
Sb ppb				
Te ppb				
Cs ppm				
Ba	130	(a)	140	140 (b)
La			14.2	14.2 (b)
Ce			36	37 (b)
Pr				
Nd			27	24 (b)
Sm			6.6	6.6 (b)
Eu			1.21	1.23 (b)
Gd				
Tb			1.2	1.2 (b)
Dy			7.8	8 (b)
Ho				
Er				
Tm				
Yb	3.6	(a)	4.7	4.6 (b)
Lu			0.66	0.63 (b)
Hf			4.5	4.5 (b)
Ta			0.56	0.6 (b)
W ppb				
Re ppb				
Os ppb				
Ir ppb			15	(b)
Pt ppb				
Au ppb			10	(b)
Th ppm			2.3	2.3 (b) 2.47 (c)
U ppm			0.66	0.7 (b) 0.67 (c)

technique: (a) various, (b) INAA, (c) radiation counting

**Table 2. Chemical composition of 69941.**

reference weight	Haskin74	Rose73	Laul73	Rancitelli73	Korotev91
SiO <sub>2</sub> %	46.3	(a) 44.67	(c )		
TiO <sub>2</sub>	0.73	(a) 0.63	(c ) 0.6	(b)	
Al <sub>2</sub> O <sub>3</sub>	24.2	(a) 26.3	(c ) 26.4	(b)	
FeO	5.41	(a) 5.76	(c ) 5.7	(b)	5.52
MnO	0.075	(a) 0.07	(c ) 0.068	(b)	
MgO	6.11	(a) 6.35	(c ) 6.4	(b)	
CaO	14.2	(a) 15.57	(c ) 15.4	(b)	15.4
Na <sub>2</sub> O	0.47	(a) 0.42	(c ) 0.47	(b)	0.45
K <sub>2</sub> O	0.118	(a) 0.14	(c ) 0.11	(b) 0.14	(d)
P <sub>2</sub> O <sub>5</sub>			0.12	(c )	
S % sum					
Sc ppm	10	(b) 12.7	10	(b)	9.94
V		31	26	(b)	
Cr		890	739	(b)	802
Co	32.1	(b) 34	29	(b)	26.3
Ni	470	(b) 545	460	(b)	382
Cu		8.3			
Zn	32	(b) 27			
Ga	4.5	(b) 3.3			
Ge ppb					
As					
Se					
Rb	2.9	(b) 3.4			
Sr		120			164
Y		58			(b)
Zr		218	140	(b)	177
Nb		14			(b)
Mo					
Ru					
Rh					
Pd ppb					
Ag ppb					
Cd ppb					
In ppb					
Sn ppb					
Sb ppb					
Te ppb					
Cs ppm	0.14	(b)			0.16
Ba		140	130		(b)
La	14.2	(b)	14		158
Ce	37	(b)	34		(b)
Pr					36.9
Nd	24	(b)	25		(b)
Sm	6.8	(b)	6.2		23
Eu	1.28	(b)	1.21		(b)
Gd	8.3	(b)			6.66
Tb	1.41	(b)	1.2		(b)
Dy	9	(b)	7.8		1.21
Ho					(b)
Er					
Tm					
Yb	4.81	(b) 3.9	4.7		1.3
Lu	0.68	(b)	0.66		(b)
Hf	5.3	(b)	4.5		0.574
Ta			0.59		(b)
W ppb					
Re ppb					
Os ppb					
Ir ppb			13	(b)	
Pt ppb					11.4
Au ppb			9		(b)
Th ppm			2.2	2.44	(d)
U ppm			0.67	0.6	(d)
technique:	(a) AA, (b) INAA, (c) various, (d) radiation counting				

**Table 3. Chemical composition of 69961.**

reference weight	Laul73	Rose73	Rancitelli73
SiO <sub>2</sub> %		44.76	(a)
TiO <sub>2</sub>	0.61	(b) 0.6	(a)
Al <sub>2</sub> O <sub>3</sub>	26.2	(b) 26.35	(a)
FeO	5.7	(b) 5.76	(a)
MnO	0.068	(b) 0.07	(a)
MgO	6.4	(b) 6.33	(a)
CaO	14.5	(b) 15.55	(a)
Na <sub>2</sub> O	0.47	(b) 0.41	(a)
K <sub>2</sub> O	0.11	(b) 0.14	(a) 0.14
P <sub>2</sub> O <sub>5</sub>		0.12	(a)
S % sum			
Sc ppm	10	(b) 11.8	(a)
V	22	(b) 29	(a)
Cr	732	(b) 890	(a)
Co	30	(b) 47	(a)
Ni	460	(b) 600	(a)
Cu		8.7	(a)
Zn		31	(a)
Ga		3.2	(a)
Ge ppb			
As			
Se			
Rb		2.9	(a)
Sr		135	(a)
Y		52	(a)
Zr	160	(b) 229	(a)
Nb		13	(a)
Mo			
Ru			
Rh			
Pd ppb			
Ag ppb			
Cd ppb			
In ppb			
Sn ppb			
Sb ppb			
Te ppb			
Cs ppm			
Ba	140	(b) 140	(a)
La	14.1	(b)	
Ce	34	(b)	
Pr			
Nd	22	(b)	
Sm	6.4	(b)	
Eu	1.22	(b)	
Gd			
Tb	1.2	(b)	
Dy	7.6	(b)	
Ho			
Er			
Tm			
Yb	4.7	(b) 3.7	(a)
Lu	0.64	(b)	
Hf	4.5	(b)	
Ta	0.59	(b)	
W ppb			
Re ppb			
Os ppb			
Ir ppb		15	(b)
Pt ppb			
Au ppb	9	(b)	
Th ppm	2.2	(b)	
U ppm	0.64	(b)	0.61
technique:	(a) AA, (b) INAA, (c) various, (d) radiation counting		

## References for 69921, 41, 61

- References for 69921, 41, 61**

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